

10/049214

OK

## PATENT COOPERATION TREATY

60/147652

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: MICHAEL POLACEK  
BAKER HUGHES INC.  
3900 ESSEX LANE  
SUITE 1200  
HOUSTON TX 77027

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of Mailing  
(day/month/year)

14 MAY 2001

Applicant's or agent's file reference

214-12988-WO

REPLY DUE

within TWO months  
from the above date of mailing

International application No.

PCT/US00/20334

International filing date (day/month/year)

26 JULY 2000

Priority date (day/month/year)

06 AUGUST 1999

International Patent Classification (IPC) or both national classification and IPC  
Please See Supplemental Sheet.

Applicant

BAKER HUGHES INC.

1. This written opinion is the first (first, etc.) drawn by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step or industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. ~~The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).~~

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also For an additional opportunity to submit amendments, see Rule 66.4.  
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.  
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 06 DECEMBER 2001

Name and mailing address of the IPEA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

CHRISTOPHER UPTON

Telephone No. (703) 308-3741

WRITTEN OPINION

International application No.

PCT/US00/20334

**I. Basis of the opinion**

1. With regard to the elements of the international application:\*

- ☒ the international application as originally filed
- ☒ the description:  
 pages 1-12 , as originally filed  
 pages NONE , filed with the demand  
 pages NONE , filed with the letter of \_\_\_\_\_
- ☒ the claims:  
 pages 13-19 , as originally filed  
 pages NONE , as amended (together with any statement) under Article 19  
 pages NONE , filed with the demand  
 pages NONE , filed with the letter of \_\_\_\_\_
- ☒ the drawings:  
 pages 1-3 , as originally filed  
 pages NONE , filed with the demand  
 pages NONE , filed with the letter of \_\_\_\_\_
- ☒ the sequence listing part of the description:  
 pages NONE , as originally filed  
 pages NONE , filed with the demand  
 pages NONE , filed with the letter of \_\_\_\_\_

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.  
 These elements were available or furnished to this Authority in the following language \_\_\_\_\_ which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the written opinion was drawn on the basis of the sequence listing:

- ☐ contained in the international application in printed form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

- ☒ the description, pages NONE
- ☒ the claims, Nos. NONE
- ☒ the drawings, sheets/fig NONE

5. ☐ This opinion has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to

WRITTEN OPINION

International application No.

PCT/US00/20334

**V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. statement**

Novelty (N)	Claims	<u>4, 10, 13, 14</u>	YES
	Claims	<u>1-3, 5-9, 11, 12, 15-23</u>	NO
Inventive Step (IS)	Claims	<u>14</u>	YES
	Claims	<u>1-13, 15-23</u>	NO
Industrial Applicability (IA)	Claims	<u>1-23</u>	YES
	Claims	<u>NONE</u>	NO

**2. citations and explanations**

Claims 1-3, 5-9, 11, 12 and 15-20 lack novelty under PCT Article 33(2) as being anticipated by the patent to Duff.

The patent to Duff discloses a clarifier with an inlet, overflow launder and underflow discharge port, and having a deliquifying member in the form of a tube (24) with a lower opening and inclined members (36, 43), with a lower rake (22) having a plurality of vertical pickets (102), as claimed.

Claims 18-21 lack novelty under PCT Article 33(2) as being anticipated by the patent to Parker.

The patent to Parker discloses a clarifier with an inlet, overflow launder and underflow discharge port, and further having a deliquifying tube(11) with a plurality of spaced openings (see figure 2), a rake (14) and a chemical injector ( 4), as claimed.

Claims 1-4, 6-11, 13, 16 and 17 lack an inventive step under PCT Article 33(3) as being obvious over Parker in view of Weber.

Claims 1-4, 6-11, 13, 16 and 17 differ from Parker in recitation of the rake having a plurality of vertical pickets. It is known to add vertical pickets to the bottom rake in a multiple level clarifier, as shown by Weber. It would therefore have been obvious for the routineer in the art of clarifier design to provide such pickets, for the purpose of aiding the release of water from the sludge blanket.

Claims 18-22 lack novelty under PCT Article 33(2) as being anticipated by the patents to Kamp or Soriente.

The patents to Kamp and Soriente each disclose clarifiers each having an inlet, an overflow launder, a rake and an underflow discharge port having upflow deliquifying tubes with flocculent injection means, as claimed.

Claims 18-23 lack novelty under PCT Article 33(2) as being (Continued on Supplemental Sheet.)

**Supplemental Box**

(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

**TIME LIMIT:**

The time limit set for response to a Written Opinion may not be extended. 37 CFR 1.484(d). Any response received after the expiration of the time limit set in the Written Opinion will not be considered in preparing the International Preliminary Examination Report.

**CLASSIFICATION:**

The International Patent Classification (IPC) and/or the National classification are as listed below:  
IPC(7): B01D 21/06, 21/08, 21/18, 21/24, 21/28  
and US Cl.: 210/712, 715, 803, 805, 197, 207, 528

**V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):**  
anticipated by the patent to Hirsch.

The Hirsch patent discloses a clarifier having an inlet, overflow launder and underflow discharge port, and further having an upflow deliquifying tube and a flocculent injection means, including an injection means adjacent the upper end of the deliquifying tube (57), as claimed. A rake (72) is also shown in figure 6.

Claim 14 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest a clarifier having a rake with a plurality of vertical pickets; and a deliquifying means extending from the lower portion to the upper portion of the tank, which is open at its lower end, upper end, and further with a plurality of spaced openings located along the length of the member each having an inclined member extending over the openings.

Claims 1-23 meet the criteria set out in PCT Article 33(4) because the invention has industrial applicability in the field of clarification.

## ----- NEW CITATIONS -----

US 3,473,661 A (DUFF) 21 October 1969, see figure 1.

US 4,392,955 A (SORIENTE) 12 July 1983, see figure 1.

US 2,370,356 A (KAMP et al) 27 February 1945, see figure 1.

US 3,353,676 A (HIRSCH) 21 November 1967, see figure 5.

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 B01D21/06 B01D21/08 B01D21/18 B01D21/24 B01D21/28

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 473 297 A (PARKER)	
Y	14 June 1949 (1949-06-14)	18-20
	the whole document	1-4, 6, 7, 9-11, 13, 16, 17
Y	US 2 253 878 A (WEBER)	
	26 August 1941 (1941-08-26)	1-4, 6, 7, 9-11, 13, 16-20
	the whole document	
Y	US 2 460 834 A (LOGUE)	
	8 February 1949 (1949-02-08)	1-3, 6, 7, 16-20
	the whole document	
	---	
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- \*Z\* document member of the same patent family

Date of the actual completion of the international search

20 November 2000

Date of mailing of the international search report

27/11/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

De La Morinerie, B

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 1 718 871 A (NORDELL) 25 June 1929 (1929-06-25)  the whole document	1-4, 9-14, 18-20
A	US 2 570 304 A (BACH) 9 October 1951 (1951-10-09) the whole document	1,2,6,7, 9-20
A	US 1 686 203 A (COE) 2 October 1928 (1928-10-02) the whole document	1,18
A	EP 0 585 103 A (TECHNOLOGY FINANCE CORP) 2 March 1994 (1994-03-02) cited in the application figure 7	21
A	US 1 526 197 A (AHLQVIST) 10 February 1925 (1925-02-10)	

See 5,433,862  
5,549,827

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

RECD 66 NOV 2001

Applicant's or agent's file reference 214-12988-WO	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/409)	
International application No. PCT/US00/20334	International filing date (day/month/year) 26 JULY 2000	Priority date (day/month/year) 06 AUGUST 1999
International Patent Classification (IPC) or national classification and IPC Please See Supplemental Sheet.		
Applicant BAKER HUGHES INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of \_\_\_\_\_ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability, citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand  06 MARCH 2001	Date of completion of this report  05 OCTOBER 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer  CHRISTOPHER UPTON <i>Chris Upton</i> Telephone No. (703) 308-3741

**I. Basis of the report****1. With regard to the elements of the international application:\***☒ the international application as originally filed☒ the description:pages 1-12, as originally filedpages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_☒ the claims:pages 13-19, as originally filedpages NONE, as amended (together with any statement) under Article 19pages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_☒ the drawings:pages 1-3, as originally filedpages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_☒ the sequence listing part of the description:pages NONE, as originally filedpages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_**2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.**

These elements were available or furnished to this Authority in the following language \_\_\_\_\_ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).☐ the language of publication of the international application (under Rule 48.3(b)).☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).**3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:**☐ contained in the international application in printed form.☐ filed together with the international application in computer readable form.☐ furnished subsequently to this Authority in written form.☐ furnished subsequently to this Authority in computer readable form.☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.**4. ☒ The amendments have resulted in the cancellation of:**☒ the description, pages NONE☒ the claims, Nos. NONE☒ the drawings, sheets/fig NONE**5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).\*\***

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

\*\*Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.



**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability, citations and explanations supporting such statement****1. statement**

Novelty (N)	Claims	<u>4, 10, 13, 14</u>	YES
	Claims	<u>1-3, 5-9, 11, 12, 15-23</u>	NO
Inventive Step (IS)	Claims	<u>14</u>	YES
	Claims	<u>1-13, 15-23</u>	NO
Industrial Applicability (IA)	Claims	<u>1-23</u>	YES
	Claims	<u>NONE</u>	NO

**2. citations and explanations (Rule 70.7)**

Claims 1-3, 5-9, 11, 12 and 15-20 lack novelty under PCT Article 33(2) as being anticipated by the patent to Duff.

The patent to Duff discloses a clarifier with an inlet, overflow launder and underflow discharge port, and having a deliquifying member in the form of a tube (24) with a lower opening and inclined members (36, 43), with a lower rake (22) having a plurality of vertical pickets (102), as claimed.

Claims 18-21 lack novelty under PCT Article 33(2) as being anticipated by the patent to Parker.

The patent to Parker discloses a clarifier with an inlet, overflow launder and underflow discharge port, and further having a deliquifying tube(11) with a plurality of spaced openings (see figure 2), a rake (14) and a chemical injector (4), as claimed.

Claims 1-4, 6-11, 13, 16 and 17 lack an inventive step under PCT Article 33(3) as being obvious over Parker in view of Weber.

Claims 1-4, 6-11, 13, 16 and 17 differ from Parker in recitation of the rake having a plurality of vertical pickets. It is known to add vertical pickets to the bottom rake in a multiple level clarifier, as shown by Weber. It would therefore have been obvious for the routineer in the art of clarifier design to provide such pickets, for the purpose of aiding the release of water from the sludge blanket.

Claims 18-22 lack novelty under PCT Article 33(2) as being anticipated by the patents to Kamp or Soriente.

The patents to Kamp and Soriente each disclose clarifiers each having an inlet, an overflow launder, a rake and an underflow discharge port having upflow deliquifying tubes with flocculent injection means, as claimed.

Claims 18-23 lack novelty under PCT Article 33(2) as being (Continued on Supplemental Sheet.)

**Supplemental Box**

(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

**CLASSIFICATION:**

The International Patent Classification (IPC) and/or the National classification are as listed below:

IPC(7): B01D 21/06, 21/08, 21/18, 21/24, 21/28

and US Cl.: 210/712, 715, 803, 805, 197, 207, 528

**V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):**

anticipated by the patent to Hirsch.

The Hirsch patent discloses a clarifier having an inlet, overflow launder and underflow discharge port, and further having an upflow deliquifying tube and a flocculent injection means, including an injection means adjacent the upper end of the deliquifying tube (57), as claimed. A rake (72) is also shown in figure 6.

Claim 14 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest a clarifier having a rake with a plurality of vertical pickets; and a deliquifying means extending from the lower portion to the upper portion of the tank, which is open at its lower end, upper end, and further with a plurality of spaced openings located along the length of the member each having an inclined member extending over the openings.

Claims 1-23 meet the criteria set out in PCT Article 33(4) because the invention has industrial applicability in the field of clarification.

## ----- NEW CITATIONS -----

US 3,473,661 A (DUFF) 21 October 1969, see figure 1.

US 4,392,955 A (SORIENTE) 12 July 1983, see figure 1.

US 2,370,356 A (KAMP et al) 27 February 1945, see figure 1.

US 3,353,676 A (HIRSCH) 21 November 1967, see figure 5.

From the INTERNATIONAL BUREAU

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner  
US Department of Commerce  
United States Patent and Trademark  
Office, PCT  
2011 South Clark Place Room  
CP2/5C24  
Arlington, VA 22202  
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 16 May 2001 (16.05.01)	
International application No. PCT/US00/20334	Applicant's or agent's file reference 214-12988-WO
International filing date (day/month/year) 26 July 2000 (26.07.00)	Priority date (day/month/year) 06 August 1999 (06.08.99)
Applicant BEDELL, Daniel	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
06 March 2001 (06.03.01)

☐ in a notice effecting later election filed with the International Bureau on:  
\_\_\_\_\_

2. The election ☒ was  
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Olivia TEFY Telephone No.: (41-22) 338.83.38
---	---

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>241-12988-W0</b>	<b>FOR FURTHER ACTION</b> <small>see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.</small>	
International application No. <b>PCT/US 00/ 20334</b>	International filing date ( <i>day/month/year</i> ) <b>26/07/2000</b>	(Earliest) Priority Date ( <i>day/month/year</i> ) <b>06/08/1999</b>
Applicant  <b>BAKER HUGHES INCORPORATED</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.  
☒ It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1 \_\_\_\_\_  
☐ None of the figures.

●/US 00/20334

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7    B01D21/06    B01D21/08    B01D21/18    B01D21/24    B01D21/28

IPC 7 B01D

EPO-Internal

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 473 297 A (PARKER)	18-20
Y	14 June 1949 (1949-06-14) the whole document	1-4, 6, 7, 9-11, 13, 16, 17
Y	--- US 2 253 878 A (WEBER) 26 August 1941 (1941-08-26)  the whole document	1-4, 6, 7, 9-11, 13, 16-20
Y	--- US 2 460 834 A (LOGUE) 8 February 1949 (1949-02-08) the whole document  --- -/--	1-3, 6, 7, 16-20

**X** Patent family members are listed in annex.

\*&\* document member of the same patent family

27/11/2000

De La Morinerie, B

## INTERNATIONAL SEARCH REPORT

International Application No

US 00/20334

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 1 718 871 A (NORDELL) 25 June 1929 (1929-06-25)  the whole document ----	1-4, 9-14, 18-20
A	US 2 570 304 A (BACH) 9 October 1951 (1951-10-09) the whole document ----	1,2,6,7, 9-20
A	US 1 686 203 A (COE) 2 October 1928 (1928-10-02) the whole document ----	1,18
A	EP 0 585 103 A (TECHNOLOGY FINANCE CORP) 2 March 1994 (1994-03-02) cited in the application figure 7 ----	21
A	US 1 526 197 A (AHLQVIST) 10 February 1925 (1925-02-10) -----	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

US 00/20334

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2473297	A	14-06-1949	NONE	
US 2253878	A	26-08-1941	DE 869792 C FR 859013 A GB 533299 A NL 62586 C NL 94813 C US 2253543 A	09-12-1940     26-08-1941
US 2460834	A	08-02-1949	NONE	
US 1718871	A	25-06-1929	NONE	
US 2570304	A	09-10-1951	GB 635591 A US 2570804 A	09-10-1951
US 1686203	A	02-10-1928	NONE	
EP 0585103	A	02-03-1994	AT 192942 T AU 667938 B AU 4484393 A CA 2104648 A DE 69328655 D GB 2270853 A, B US 5433862 A US 5549827 A ZA 9306167 A	15-06-2000 18-04-1996 03-03-1994 25-02-1994 21-06-2000 30-03-1994 18-07-1995 27-08-1996 17-03-1994
US 1526197	A	10-02-1925	NONE	

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
15 February 2001 (15.02.2001)

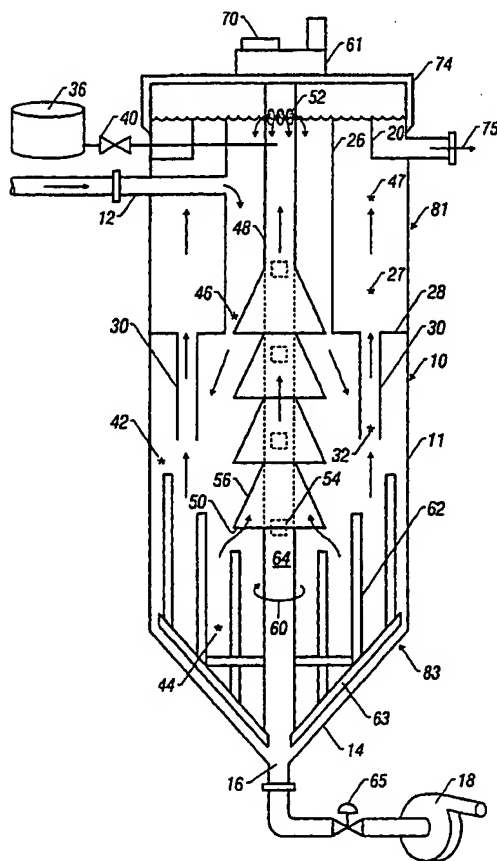
PCT

(10) International Publication Number  
WO 01/10530 A1

- (51) International Patent Classification<sup>7</sup>: B01D 21/06, 21/08, 21/18, 21/24, 21/28
- (21) International Application Number: PCT/US00/20334
- (22) International Filing Date: 26 July 2000 (26.07.2000)
- (25) Filing Language: English
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- (30) Priority Data:  
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(54) Title: DEEP BED THICKENER/CLARIFIERS WITH ENHANCED LIQUID REMOVAL



(57) Abstract: The enhanced deliquifying of the compacted bed of deep bed thickener/clarifier is disclosed. Such an apparatus comprises a vessel receiving a slurry of liquid and solid particles suspended in the liquid. The vessel defines a free settling zone, a hindered settling zone intermediate, an upper clarification zone and a lower compaction zone. A deliquifying member is provided in the vessel extending up between at least two zones for facilitating the upward flow of free liquid from one of the lower zones and the settling of particulates. A rotating rake shaft with pickets are so designed to release the interstitial liquid trapped in a lower zone. The pickets provide pathways for liquid to release generally vertically. The released liquid travels upward to the deliquifying member and on into the clarification zone. The lower zone, freed of the interstitial water, further collapses becoming more concentrated or dense.

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patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

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**DEEP BED THICKENER/CLARIFIERS WITH ENHANCED  
LIQUID REMOVAL****BACKGROUND OF THE INVENTION**

This invention relates to clarifiers and thickeners of the deep bed type. This invention also relates to an associated method for separating liquid and solid particles in a suspension of slurry in thickness and clarifiers.

5        Deep bed thickeners and clarifiers (or so-called thickener/clarifier devices) are shown and described, for example, in U.S. Patent Nos. 5,433,862, 5,549,827 and 5,800,715, the disclosures of which are hereby incorporated by reference herein.

10        The device described in U.S. Patent No. 5,433,862 comprises a vessel receiving a slurry of liquid and solid particles suspended on the liquid. The vessel defines a hindered settling zone in which the liquid and solids of the slurry tend to separate, with the solids settling down into a compaction zone below the hindered settling zone. In the compaction zone, the solids concentration tends to increase, while the liquid phase rises to a  
15        clarification zone above the hindered settling zone. An overflow launder, adjacent the upper end of the vessel, receives the overflow phase of the slurry separated in the vessel. An underflow discharge port toward the bottom of the vessel receives the thickened or underflow phase of the slurry separated in the vessel. One or more so-called separating members are  
20        provided in the vessel extending upwardly from a lower end in the hindered settling or compaction zones to an upper end in a clarification zone. Preferably, this member includes cones or other downwardly inclined surfaces that facilitate both the settling of solids down to the compaction zone and the upward flow of free liquid from the hindered settling and/or  
25        compaction zone to the clarification zone.

The deep bed thickener or clarifier device described in U.S. Patent No. 5,800,715 is similar to that disclosed in U.S. Patent No. 5,433,862, but further has a fluid flow barrier between the overflow clarification zone and the other zones of the vessel, and one or more clarifying conduits extending  
5 through the barrier. Each such conduit carries a suspended floc bed of particulate solids that filters and further clarifies the liquid flowing up from the hindered settling zone to the clarification zone. This further filtering removes solid particles that would otherwise be carried along the "clarified" liquid to the overflow launder. These clarification conduits thus serve a  
10 significantly different purpose than do the separating members and function independently thereof.

Deep bed thickener/clarifiers offer certain design and operational advantages over the conventional thickeners and clarifiers while providing clarity of overflow and solids concentration of underflow comparable to that  
15 of conventional thickener/clarifiers. Such thickeners and clarifiers are typically of low-profile design (i.e., shorter in height but of much greater diameter than deep bed thickeners), but like deep bed thickeners have generally central feedwells and underflow underflow discharge ports.

Conventional low profile thickeners rely on the radial expanse of the  
20 horizontal settling zones to effect settling of the slurry throughout the thickener. To achieve this settling action, the influent feed is typically dispersed radially outwardly from the central feedwell and rotating rake arms, having generally plow shaped blades, gather and laterally direct the settled solids along the thickener/clarifier bottom to the central discharge  
25 opening in the bottom of the thickener/clarifier tank. These rake blades are located closely adjacent the tank bottom and are designed to move the solids across the tank bottom with minimal disruption in the downward (or settling) flow pattern of the slurry through the hindered settling and

compaction zones. Consistent with this purpose, the rakes are rotated at a very slow speed, for example, less than 1 revolution per minute. U.S. Patent Nos. 4,082,671, 4,217,916 and 4,271,027, for example, describe and illustrate rake assemblies that perform this function of moving settled solids across the tank bottom of conventional low-profile thickeners for discharge at a central underflow outlet. Indeed, some of the rake assemblies are intended to scrape the settled solids from the tank bottom, see U.S. Patent No. 4,247,400.

In contrast, "deep bed" thickener/clarifiers rely on the height of the hindered settling to cause separation of the slurry into its clarified liquid and settled solids phases. Deep bed thickeners/clarifiers further have a deep, high angle conical bottom for directing the settled solids toward the discharge opening. Thus there is no need for rotating rakes to move the solids within the thickener/clarifier to effect removal of the solids. Indeed, rakes would serve little purpose in moving the solid, but rather would add expense and operating complexity.

Basically, deep bed thickeners rely on a conical tank bottom having a sidewall extending an angle from horizontal generally greater than the angle of repose of the settled solids to direct the solids to move by gravity alone along the tank bottom to the discharge opening. This eliminates the need for a rotating rake and thereby simplifies the operation and construction of the thickener/clarifier as well as reduces the cost of the thickener/clarifier compared to conventional thickeners/clarifiers. This cost reduction takes the form of the elimination of a capital expenditure for the rake assemblies, as well as the elimination of the associated torque driveheads and motors (often in excess of 1,000,000 foot pounds torque) and high strength bridges spanning the tank top to support the drive.

In contrast, conventional low profile thickener/clarifiers have tank bottoms that are flat or inclined at angles generally below the angle of repose of the settled solids and thus require rake assemblies and the associated drive and bridge (or column) structures to remove the settled solids from the thickener/clarifier.

### SUMMARY OF THE INVENTION

The present invention enhances liquid-solids separation in a deep bed thickener/clarifier and thus produces an underflow product or sludge which is thickened relative to that of existing deep bed thickeners/clarifiers.

More particularly, the deep bed thickener/clarifier of this invention provides for the release and removal of free or interstitial liquid (typically water) trapped in the settled solids in the hindered settling zone and/or the compaction zone. This release of liquid is effected without increasing the size of the thickener/clarifier, disturbing the settling processes or the naturally occurring movement of the solids along the conical tank bottom.

The deep bed thickener/clarifier of the present invention comprises a vessel with an overflow launder and an underflow discharge port. The vessel has an inlet for receiving a slurry of a liquid and solid particles suspended in the liquid. In an upper portion of the vessel, a free settling zone has a low concentration of solid slurry particles, while in a lower portion of the vessel, a compaction zone has a high concentration of solid slurry particles. The overflow launder is attached to the vessel adjacent an upper end thereof for discharge of an overflow phase of the slurry that has been separated in the vessel. The underflow discharge port is adjacent to a bottom thereof for discharge of a thickened, underflow phase of the slurry that has been separated in the vessel.

An upper portion of the vessel holds the free settling zone and a lower portion of the vessel holds the compaction zone. A hindered settling

zone extends between the free settling and compaction zones, with the hindered settling zone and compaction zone constituting lower settling zones. A deliquifying member is positioned in the vessel extending up from adjacent the lower portion of the vessel to adjacent the upper portion of the vessel for flow of liquid from at least one of the lower zones to the free settling zone. The deliquifying member further serves to isolate this flow of liquid from the flow of slurry down in the lower settling zones. A rake assembly is mounted for rotation in the lower portion of the vessel, with the rake assembly forming channels in the slurry held in the lower portion of the vessel for releasing liquid in at least one of said lower settling zones to flow to the deliquifying member and on to the free settling zone.

The method of this invention for operating a deep bed thickener/clarifier comprises, in accordance with the present invention, feeding, into a vessel, a slurry of a liquid and solid particles suspended in the liquid and separating the slurry by gravity into different zones having respective degrees of liquid-solids separation including, at an upper portion of the vessel, a free settling zone having a low concentration of solid slurry particles and further including, at a lower portion of the vessel, a compaction zone having a high concentration of solid slurry particles. A hindered settling zone is positioned between these zones. The method also comprises discharging, into an overflow launder attached to the vessel proximately to an upper end thereof, an overflow phase of the slurry that has been separated in the clarification zone and discharging, via an underflow discharge port fixed to the vessel at least proximately to a bottom thereof, a thickened, underflow phase of the slurry that has been separated in the vessel. Liquid is directed from at least one of the lower settling zones to the free settling zone via a flow path which is isolated from the flow of slurry down in the vessel in the lower settling zones. In accordance with this

invention, upwardly extending channels are formed in the slurry held in the lower portion of the vessel to release liquid in at least one of the lower settling zones to flow to the isolated flow path and then to the free settling zone.

5 Other objects of the invention will be in part apparent and in part described and shown in the following description of the drawings and preferred embodiments.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

For detailed understanding of the present invention, reference should  
10 be made to the following detailed description of the preferred embodiments, taken in conjunction with the accompanying drawings, in which like elements have been given like numerals and wherein:

**FIG. 1** illustrates a vertical section of the thickener/clarifier of this invention and its various components including the deliquifying member  
15 and a rake assembly;

**FIG. 2** illustrates a vertical section of a second thickener/clarifier of this invention with the rake shaft passing through the inside of the deliquifying member; and

**FIG. 3** illustrates the enlarged detail of a rake picket in the slurry for  
20 forming a water flow channel in the slurry.

### **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

As illustrated in **FIG. 1**, a deep bed thickener/clarifier of this invention, generally indicated at 10, comprises a vessel 11 having an inlet 12 receiving a slurry comprising liquid and solid particles suspended in the  
25 liquid. The slurry components are separated in vessel 11 into a relatively light-weight overflow phase (i.e., a primarily clarified liquid) and a relatively heavy underflow phase (i.e., a primarily high solid concentration). Vessel 11 includes a downwardly tapering frusto-conical bottom 14 having

an apex (not designated) connected to an underflow discharge port 16 for the discharge of the thickened, underflow phase of the slurry that has been separated in vessel 11. A variable speed pump and motor 18 communicate via a valve 65 with discharge port 16 for the controlled removal of the underflow from vessel 11. Alternatively, a remotely actuated valve (not shown) may be provided as a mechanical end use device at discharge port 16 to control the removal of the underflow.

The thickener/clarifier 10 further includes an overflow weir or launder 20 for removal of the overflow phase separated from the slurry in vessel 11. An upper lip (not designated) of launder 20 defines the upper level of the clarified liquid. A cylindrical wall 26 in vessel 11 forms an annular chamber 27 and defines a fluid barrier between the annular chamber and the remainder of the vessel interior. Projecting through a lower wall or panel 28 of annular chamber 27 is one or more elongate conduits 30 having generally vertically extending sidewalls which support fluidized floc beds 32 of the particulate material suspended in the different conduits, as described in greater detail in U.S. Patent No. 5,800,715. Two such conduits 30 are shown in FIG. 1. However, other vessel designs may have only one such conduit or more than two conduits. Conduits 30 are shown to be of square or circular shape in section, but may be of any shape in section.

To facilitate flocculation in vessel 11, a settling agent such as a polyelectrolyte may be delivered as an additive to the slurry or as shown in FIG. 1 preferably to the free settling liquid in the vessel. As shown in FIG. 1, a source of settling agent such as a storage tank 36 is in fluid flow communication with the vessel 11. A fluid flow control device, such as a remotely actuated valve 40, regulates the dosage of settling aid delivered to the slurry and thus control the extent of floc formation within vessel 11.



The slurry received and held in vessel 11 separates by gravity into a hindered settling zone 42 which is located above a compaction zone 44 and below an interior free settling clarification zone 46 and an overflow clarification zone 47 in annular chamber 27. Within hindered settling zone 42, the liquid and solid particles tend to separate with the solid particles tending to flow downwardly to the compaction zone 44 and with the clarified liquid flowing up to clarification zone 47. Within compaction zone 44 the solids concentration increases to the highest level of concentration at discharge port or outlet 16 at the vessel bottom.

As described in U.S. Patent No. 5,433,862, a deliquifying member 48 extends up within vessel 11 from generally adjacent the compaction zone 44. Deliquifying member 48 is of generally tubular configuration and receives free liquid released from compaction zone 44 and delivers the liquid to the upper end of the deliquifying member 48 which is preferably positioned at the interior free settling clarification zone 46. At its upper end, deliquifying member 48 is provided with openings 52 for feeding expressed liquid to the free settling clarification zone 46. In the thickener/clarifier of FIG. 1, the deliquifying member 48 also serves as part of a rotary drive member or rake shaft as described more fully hereinafter.

The vessel comprises an upper portion, indicated generally at 81, holding at least a portion of the free settling zone 46 and a lower portion, indicated generally at 83, holding at least a portion of the compaction zone 44. The hindered settling zone 42 may extend into either the upper or lower portion of the vessel. The compaction zone 44 and hindered settling zone 42 constitute lower settling zones. The deliquifying member 48 in the vessel extends up from the lower portion 83 of the vessel to the upper portion 81 of the vessel for flow of liquid from at least one of the lower settling zones to the free settling zone while isolating the flow of liquid from

the flow of slurry down into the lower settling zone. A rake assembly 63 is mounted for rotation as indicated at 60 in the lower portion 83 of the vessel and has a plurality of generally vertical pickets 62. As shown in FIG. 3, as the rake assembly rotates, the pickets 62 travel through the slurry, see arrow 80, and form temporary channels 76 in the slurry held in the lower portion of the vessel. These channels release free or interstitial liquid in pockets 75 in at least one of the lower settling zones to flow along generally vertical paths 72 to the deliquifying member 48. From there, the liquid is free to flow on to the free settling zone 46. The deliquifying member 48 supports and rotates the rake assembly 63. At its upper end, deliquifying member 48 is operatively connected to a motor 70 via a drivehead 61. The motor 70 may be of fixed or variable speed, and use any suitable motive power, such as an electric or hydraulic motor or a combustion engine.

Accordingly, the deliquifying member 48 facilitates removal of free liquid from at least one of the lower zones to enable solids in the compaction zone to increase to a higher concentration level and to do so more rapidly than would otherwise be possible. The deliquifying member 48 is open to hindered settling zone 42 to facilitate release of free liquid from that zone. To that end, deliquifying member 48 is provided with one or more suitable inclined members such as upwardly tapering conical deliquifying baffles 56 shown, for example, in FIG. 1 as being ganged in a sequence. Each conical deliquifying baffle 56 is open at a lower end 50 and guides released liquid upwardly along an inner surface (not shown) to a respective opening or aperture 54 provided in deliquifying member 48. Settling solids particles are directed along the outer surfaces of conical deliquifying baffles 56 towards the bottom of vessel 11. Thus the deliquifying member 48 isolates the upward flow of liquid from the downward flow of the slurry.

Deliquifying member 48 provides a conduit for the flow of free liquid thus released from hindered settling zone 42 and compaction zone 44. This channeling of the released liquid in those zones influences the solids settling rate therein. Deliquifying member 48 is shown to be a tube of  
5 circular or square cross-section. However, deliquifying member 48 may be of other shapes as described and shown in U.S. Patent No. 5,433,862. The word "tubular" is used herein to mean a hollow profile of any suitable cross-sectional shape.

In operation, deliquifying member 48 is rotated at a slow rate during  
10 the gravity settling process. The consequent movement of the pickets 62 through the thickened slurry or sludge in the lower zones releases otherwise trapped interstitial liquid 71. This freed liquid 71 generally escapes from compaction zone 44 in laminar flow paths along pickets 62, as illustrated in FIG. 3. The overall process of thickening or clarification in apparatus 10 is  
15 controlled by adjusting the underflow withdrawal and overflow discharge rates relative to the inlet. Thickener/clarifier 10 as provided with a rotatable rake assembly 63 provides for higher underflow solids concentration, improved overflow clarity, increased rate of influent feed, reduced settling aid usage or any combination of these advantages or results than would be  
20 possible in treating slurries in conventional deep bed or low-profile, large diameter thickener/clarifiers.

Thickener/clarifier 10 includes a cover plate or upper panel 74 which carries drivehead 61 and motor 70. An outlet port 75 is provided at the upper end of vessel 11 for discharging the clarified liquid phase which spills  
25 over weir or launder 20. The deliquifying member 48 is rotatably suspended from cover plate or upper panel 74.

FIG. 2 depicts a second embodiment of the thickener/clarifier 110 which includes certain modifications with respect to the apparatus of FIG.

1. Like structures in FIGS. 1 and 2 are designated with the same reference numerals.

In FIG. 2, the deliquifying member 148, unlike the deliquifying member 48 in FIG. 1, does not serve to rotate the rake assembly and may be rigidly fixed to cover or upper panel 74. The deliquifying member 148 is also shown to terminate at an upper end of a lowermost conical deliquifying baffle 56.

Thickener/clarifier 110 includes a rotatable rake 163 having a plurality of generally parallel vertically extending pickets 162. Rake 163 serves to augment or accelerate the deliquifying of the lower zones. Rake 163 is rotated by a drive shaft 166 which is generally coaxially and longitudinally disposed in deliquifying member 148. Drive shaft 166 is rotatably journaled in cover plate or upper panel 74 and is operatively connected to drivehead 61 and motor 70.

The upper three conical deliquifying baffles 56 communicate with a lumen or interior (not designated) of fluid flow member 148 via openings or apertures 154 provided in tubular fluid flow member 148. As discussed above, settling solids particles are directed along the outer surfaces of conical deliquifying baffles 56 towards the bottom of vessel 11.

The embodiment of FIG. 2 also differs from that of FIG. 1 in not incorporating clarification tubes (such as tubes 30) and in directing flocculant to the free settling zone at the exterior of the deliquifying member 148.

Although the invention has been described in terms of its preferred embodiments, those skilled in the art will recognize that numerous modifications and changes may be made while remaining within the scope and spirit of the invention. For example, pickets 62 and 162 of rakes 63 and 163, respectively, extend parallel to one another vertically through

compaction zone 44 and into hindered settling zone 42. Pickets 62 and 162 may be alternatively inclined at an angle to the vertical. In addition, conical deliquifying baffles 56 may be greater or fewer in number than four. The conical deliquifying baffles located below chamber 27 may be larger. In addition, the pickets may be positioned and be of sufficient length to extend into both the compaction zone 44 and hindered settling zone 42. The deliquifying member 48, 148 may be open only adjacent its lower end to receive liquid from one of the lower zones and adjacent its upper end to discharge liquid conveyed by the member. Alternatively, the member may be open at a plurality of locations as well as for a substantial portion of its length.

Accordingly, it is to be understood that the drawings and description herein be offered by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

**WHAT IS CLAIMED IS:**

1. A thickener/clarifier, comprising:
  - (a) a vessel having an inlet for receiving a slurry of a liquid and solid particles suspended in the liquid, said  
5 vessel having an upper portion holding a free settling zone having a relatively low concentration of solid slurry particles and having a lower portion holding a compaction zone having a relatively high concentration of solid slurry particles and a hindered  
10 settling zone between said compaction zone and said free settling zone, with said compaction zone and said hindered settling zone constituting lower settling zones;
  - (b) an overflow launder adjacent said upper end of said  
15 vessel for discharge of an overflow phase of the slurry that has been separated in said vessel;
  - (c) an underflow discharge port adjacent said bottom of said vessel for discharge of a thickened, underflow phase of the slurry that has been separated in said  
20 vessel;
  - (d) a deliquifying member in said vessel extending up from said lower portion of said vessel to said upper portion of said vessel for flow of liquid from at least one of said lower settling zones to said free settling  
25 zone while isolating said flow of liquid from the flow of slurry down in said lower settling zones; and

- 5 (e) a rake assembly mounted for rotation in said lower portion of said vessel, with said rake assembly having at least one elongated generally vertical picket forming channels in the slurry held in said lower portion of said vessel for releasing liquid in at least one of said lower settling zones to flow to said deliquifying member and on to said free settling zone.
- 10 2. The thickener/clarifier of claim 1 wherein said rake assembly further includes a rotary drive for rotation of said rake assembly about a generally vertical axis.
- 15 3. The thickener/clarifier of claim 2 wherein said rotary drive is disposed at the upper end of said vessel, said rotary drive being connected to said rake assembly via an elongate drive member extending vertically down into said vessel.
- 20 4. The thickener/clarifier of claim 3 wherein said drive member is of tubular configuration for at least a portion of its length to receive liquid released from a lower settling zone.
- 25 5. The thickener/clarifier of claim 3 wherein said drive member is received in a tubular member surrounding said shaft, said tubular member receiving liquid released from a lower settling zone.

6. The thickener/clarifier of claim 1 wherein said rake assembly includes a plurality of pickets extending generally parallel to one-another.
- 5 7. The thickener/clarifier of claim 6 wherein said pickets extend into the compaction zone.
8. The thickener/clarifier of claim 7 wherein said pickets extend into both said compaction zone and said hindered settling zone.
- 10 9. The thickener/clarifier of claim 1 wherein said deliquifying member is open adjacent its lower end to receive liquid from at least one of said lower settling zones and is open adjacent its upper end to discharge liquid conveyed by said deliquifying member to said free settling zone.
- 15 10. The thickener/clarifier of claim 9 wherein said deliquifying member is open to receive liquid for a substantial portion of its length.
11. The thickener/clarifier of claim 9 wherein said deliquifying member is a tube with fluid flow openings therein.
- 20 12. The thickener/clarifier of claim 9 wherein said deliquifying member further comprises an inclined member extending over the opening in said deliquifying member adjacent its lower end.
- 25 13. The thickener/clarifier of claim 11 wherein said deliquifying member has openings at spaced locations along its length.
14. The thickener/clarifier of claim 13 wherein said deliquifying member has



inclined members extending over said openings in said  
deliquifying

member in said lower portion of said vessel.

15. The thickener/clarifier of claim 12 wherein said inclined  
member

comprises a conical baffle.

16. The thickener/clarifier of claim 7 wherein said deliquifying  
member is open adjacent its lower end to receive liquid from  
at least one of said lower settling zones and said at least one  
of said picket extends below said opening adjacent a lower  
end of said deliquifying member.

17. The thickener/clarifier of claim 7 wherein said at least of said  
picket is

positioned with its upper end below a lower end of said

deliquifying

member.

18. A method of operating a thickener/clarifier having an upper  
portion and a

lower portion, comprising:

(a) feeding a slurry of a liquid and solid particles  
suspended in the liquid into a vessel;

(b) separating said slurry by gravity into different zones  
having respective degrees of liquid-solids separation  
including, at a upper portion of said vessel, a free  
settling zone having a relatively low concentration of  
solid slurry particles and further including, at a lower  
portion of said vessel, a compaction zone having a  
relatively high concentration of solid slurry particles

- and a hindered settling zone between said free settling zone and said compaction zone, with said hindered zone and said compaction zone constituting lower settling zones;
- 5 (c) discharging an overflow phase of the slurry that has been separated in said vessel into an overflow launder adjacent to an upper end of said vessel;
- (d) discharging, via an underflow discharge adjacent a bottom of said vessel, a thickened, underflow phase of the slurry that has been separated in said vessel;
- 10 (e) directing liquid from at least one of said lower settling zones to flow up to said free settling zone via a flow path isolated from the flow of the slurry down in said vessel in said lower settling zones; and
- 15 (f) forming generally upwardly extending channels in the slurry held in said lower portion of said vessel to release liquid in at least one of said lower settling zones to flow to said isolated flow path and then on to said free settling zone.
- 20 19. The method of claim 18 further comprising moving a rake assembly in said lower portion of said vessel.
20. The method of claim 19 wherein said rake assembly is rotated about a generally vertical axis.
21. A thickener/clarifier, comprising:
- 25 (a) a vessel having an inlet for receiving a slurry of a liquid and solid particles suspended in the liquid, said vessel having an upper portion surrounding a free settling zone having a relatively low concentration of

5

solid slurry particles and having a lower portion surrounding a compaction zone having a relatively high concentration of solid slurry particles, and a hindered settling zone between said compaction zone and said free settling zone, with said compaction zone and said hindered settling zone constituting lower settling zones;

10

(b) an overflow launder adjacent said upper end of said vessel for discharge of an overflow phase of the slurry that has been separated in said vessel;

(c) an underflow discharge port adjacent said bottom of the vessel for discharge of a thickened, underflow phase of the slurry that has been separated in said vessel;

15

(d) a deliquifying member in said vessel extending up from said lower portion of said vessel to said upper portion of said vessel for flow of liquid to said free settling zone from at least one of said lower settling zones while isolating said flow of liquid from the flow of slurry down in said lower settling zones; and

20

(e) an injector for injecting flocculant into the flow of water to said free settling zone to facilitate settling of solid particles in the water.

25

22. The thickener/clarifier of claim 21 wherein the injector extends into said deliquifying member.

23. The thickener/clarifier of claim 21 wherein said deliquifying member includes an opening adjacent its upper end for discharge of liquid into said free settling zone and said

injector is positioned adjacent said opening in said deliquifying member.

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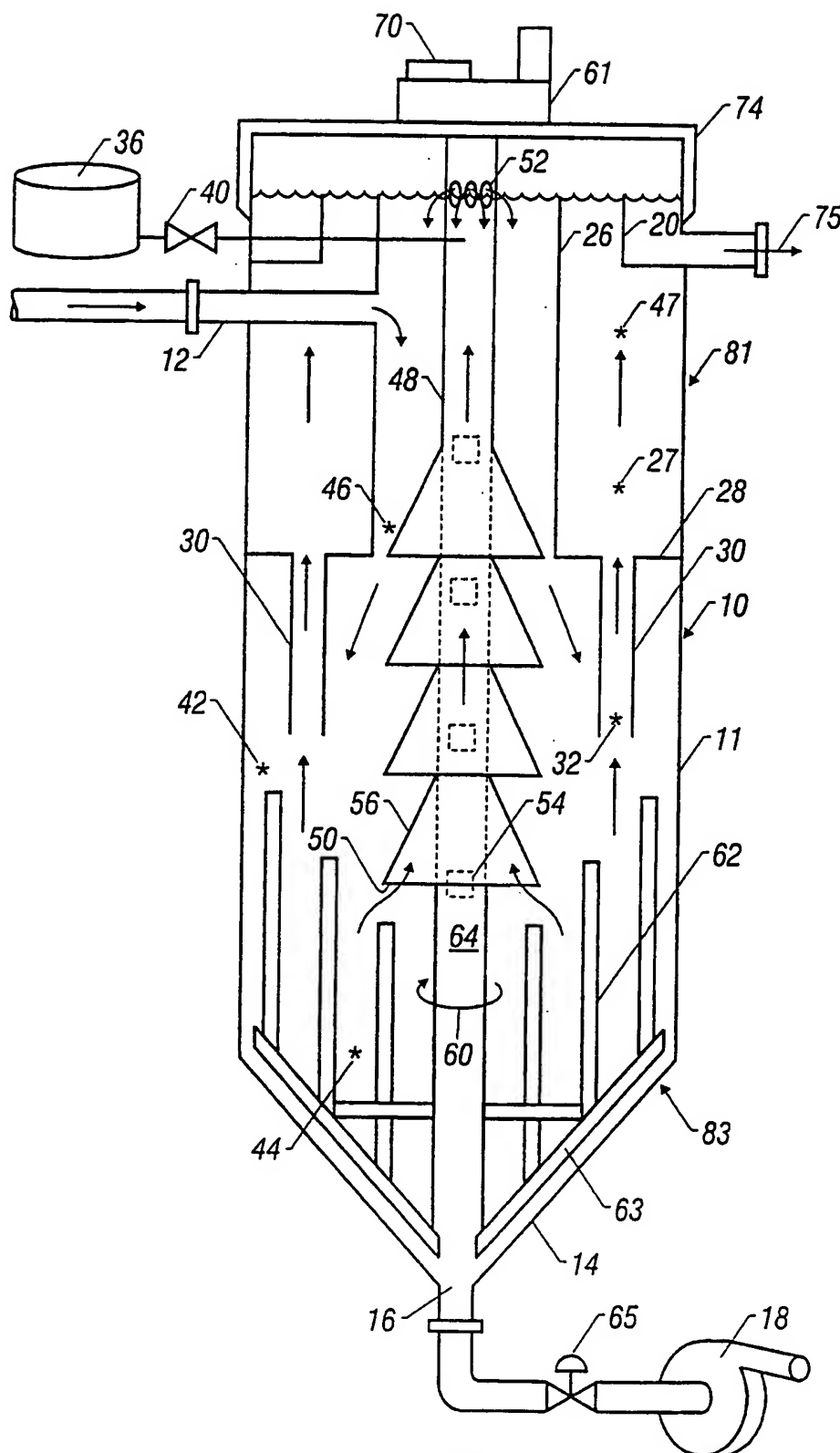


FIG. 1

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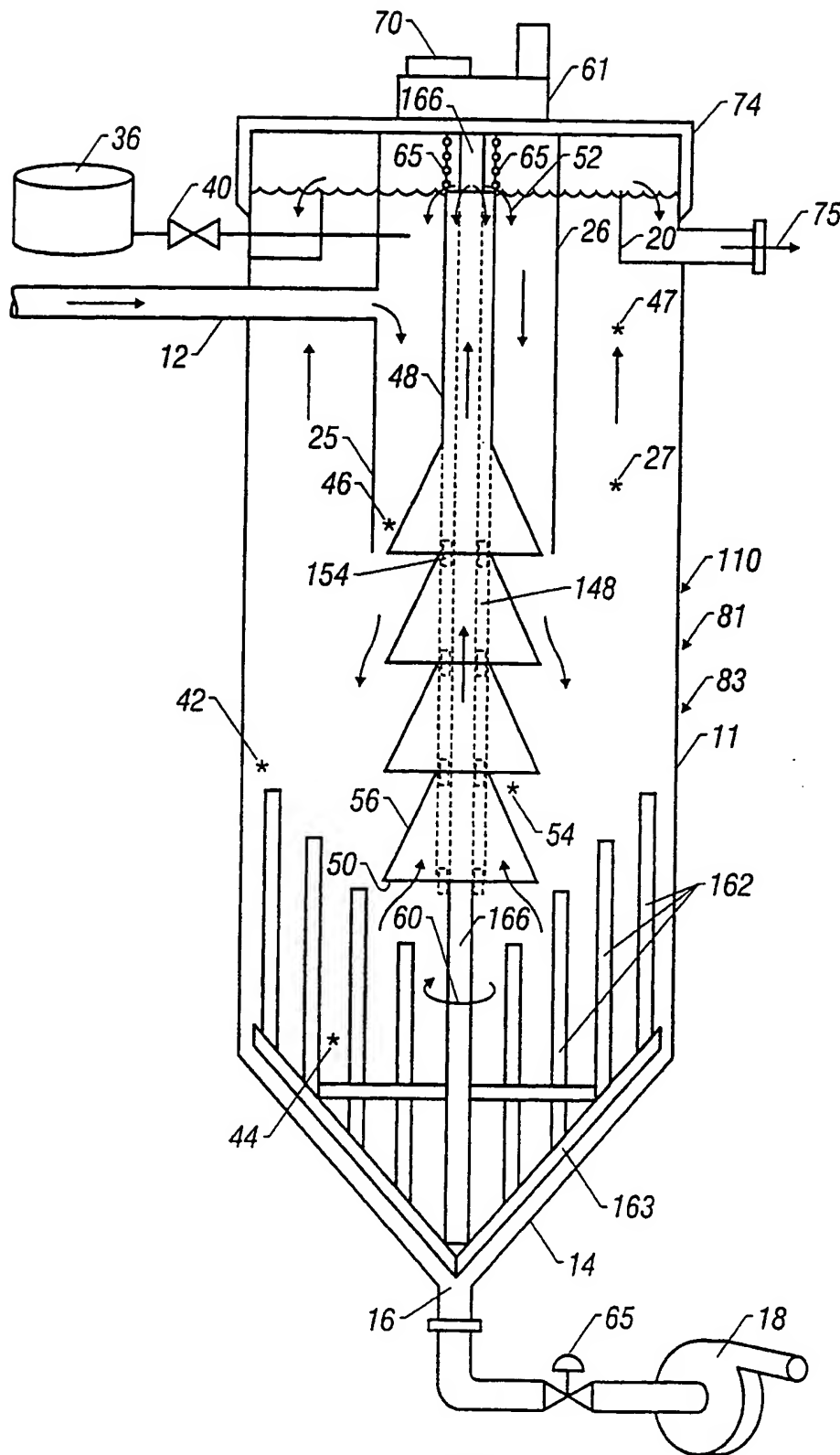


FIG. 2

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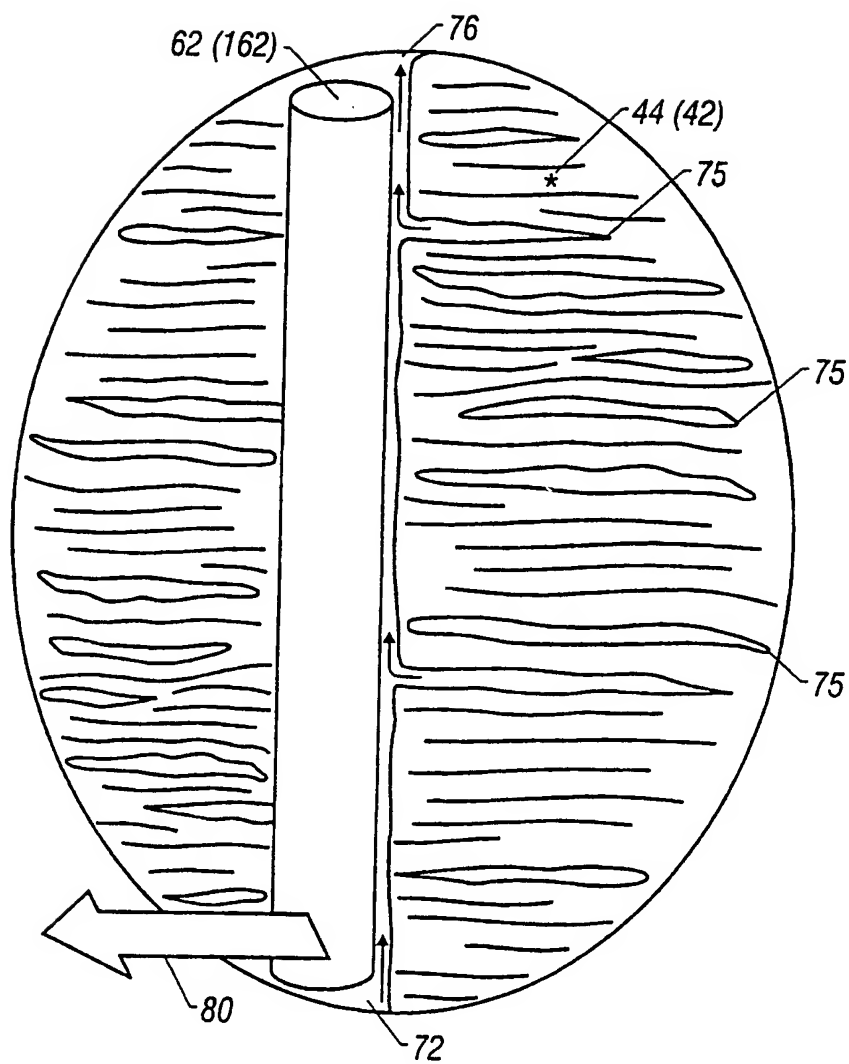


FIG. 3